Claims

[c1] 1. A method for controlling a hybrid powertrain for an automotive vehicle having a driver-controlled engine, an electric motor, a battery, a generator connected to the battery and a gear system, the power train establishing a split-power flow path for distributing power to vehicle traction wheels, the battery defining an electric power source, and the engine defining a mechanical power source, the method comprising the steps of:
delivering engine torque to a first torque input element of the gear system, delivering reaction torque of the gear system to the generator and delivering torque from a torque output element of the gear system to the traction wheels thereby establishing a power-split in a first power delivery configuration;
delivering torque from the electric power source through the gear system to the traction wheels with the engine deactivated thereby establishing a second power source configuration;
coordinating power delivery from the mechanical and electrical power sources whereby a response to driver demand for power will optimize driveline efficiency and performance without exceeding power limits for the en-

gine and the battery;
the step of coordinating power delivery from the electric power source and the mechanical power source including the steps of establishing a request for battery power and a request for engine power, monitoring actual battery power during an operating interval using a closed-loop feedback,and determining an error between the actual battery power and a requested battery power; and adjusting a battery power request during transient and steady-state operating conditions to change the request for engine power whereby the error becomes zero, the closed-loop feedback thereby minimizing unnecessary battery usage due to variable operating conditions.

[c2] 2. The method set forth in claim 1 including the step of braking the generator to establish a parallel mechanical torque flow path to the traction wheels with a fixed gear system ratio.

[c3] 3. The method set forth in claim 1 including the steps of determining a driver demand for power as a function of traction wheel speed and driver torque demand;
determining whether the driver demand for power is within predetermined engine power maximum and minimum limits; and
delivering battery power to the transmission gearing to complement the driver demand for power when the

driver demand for power is outside engine power limits.

[c4] 4. The method set forth in claim 3 including the steps of determining whether a request for battery power to complement engine power is within predetermined battery power maximum and minimum limits; and controlling battery power to avoid exceeding battery power limits thereby preventing the battery from overcharging or over-discharging.

[c5] 5. The method set forth in claim 3 wherein the step of determining driver demand for power includes the step of accounting for electrical losses in the powertrain whereby the effective demand for power is the sum of the driver demand for power and electrical power losses.

[c6] 6. A method for controlling a hybrid powertrain for an automotive vehicle having an engine, an electric motor, a battery, a generator electrically coupled to the battery and a gear system, the powertrain establishing a split-power flow path for distributing power to vehicle traction wheels, the battery defining an electrical power source and the engine defining a mechanical power source, the method comprising the steps of:
delivering engine torque to a first torque input element of the gear system, delivering reaction torque of the gear system to the generator and delivering torque form a

torque output element of the gear system to the traction wheels thereby establishing split-power delivery;
coordinating power delivery from the engine and the battery whereby a response to driver demand for power will optimize efficiency and performance without exceeding power limits for the engine and the battery;
the step of coordinating power deliver from the engine and the battery including the steps of establishing a request for battery power and a request for engine power, monitoring actual battery power during an operating interval using a closed-loop feedback,
determining an error between the actual battery power and a requested battery power; and
adjusting a battery power request during transient and steady-state operating conditions to change the request for engine power whereby the error becomes zero, the closed loop feedback thereby minimizing unnecessary battery usage due to variable operating conditions.

[c7] 7. The method set forth in claim 6 including the steps of determining a driver demand for power as a function of traction wheel speed and driver torque demand; determining whether the driver demand for power is within predetermined engine power maximum and minimum limits; and
delivering batter power to the transmission gearing to

complement the driver demand for power when the driver demand for power is outside engine power limits.

[c8] 8. The method set forth in claim 7 including the steps of determining whether a request for battery power to complement engine power is within predetermined battery power maximum and minimum limits; and controlling battery power to avoid exceeding battery power limits thereby preventing the battery from over-charging or over-discharging.

[c9] 9. The method set forth in claim 7 wherein the step of determining driver demand for power includes the step of accounting for electrical losses in the powertrain whereby the effective demand for power is the sum of the driver demand for power and electrical power losses.

[c10] 10. A closed-loop power control system for a powertrain for a hybrid electric vehicle comprising:
an engine defining in part a mechanical drive system,
a battery, a motor and a generator defining in part an electric drive system,
a planetary gear unit having a sun gear, a ring gear and a planetary carrier, the engine being connected to the carrier and the sun gear being connected to the generator;
a geared torque flow path defined by the electric drive system and the mechanical drive system extending to

vehicle traction wheels, a torque input element of the electric drive system being connected to the motor and a torque input element of the mechanical drive system being connected to the engine;

a first controller for coordinating power distribution from the engine and the battery to effect optimal powertrain performance within predefined battery power charging and discharging limits;

a second controller for receiving a request for battery power; and

a closed-loop feedback system for monitoring actual battery power during an operating interval and determining an error between the actual battery power and a requested battery power;

the second controller being connected to the closed-loop feedback system and including a software algorithm for adjusting a battery power request during transient and steady-state operation to change the request for engine power whereby the error becomes zero, thus minimizing unnecessary battery usage due to transient operating conditions.

[c11] 11. The control system set forth in claim 10 including a vehicle system controller, the vehicle system controller comprising means for limiting power distribution to the traction wheels, following a driver demand for power, to

power values within predefined power maximum and minimum system limits.

[c12] 12. The control system set forth in claim 11 including a vehicle system controller, the vehicle system controller comprises means for incrementing the driver demand for power by an amount equal to electrical power losses in the driveline whereby the incremented driver demand for power is limited to the predefined maximum and minimum system limits.

[c13] 13. A method for controlling a hybrid powertrain for a wheeled automotive vehicle having a driver-controlled engine, an electric motor, a battery, a generator connected to the battery and a gear system, the battery defining an electric power source and the engine defining a mechanical power source, the method comprising the steps of:

coordinating power delivery from the mechanical and electrical power delivery from the mechanical and electrical power sources whereby a response to driver demand for power will optimize driveline efficiency and performance without exceeding predefined power limits for the engine and the battery;

the step of coordinating power delivery from the electric power source and the mechanical power source including the steps of establishing a request for battery power and

a request for engine power, monitoring actual battery power during an operating interval using a closed-loop feedback, and determining an error between the actual battery power and a requested battery power; and
adjusting a battery power request during transient and steady-state operating conditions to change the request for engine power whereby the error becomes zero, the closed-loop feedback thereby minimizing unnecessary battery usage due to variable operating conditions.

[c14] 14. The method set forth in claim 13 including the steps of determining a driver demand for power as a function of vehicle wheel speed and driver torque demand;
determining whether the driver demand for power is within predetermined engine power maximum and minimum limits; and
delivering battery power to the transmission gearing to complement the driver demand for power when the driver demand for power is outside engine power limits.

[c15] 15. The method set forth in claim 13 including the steps of determining whether a request for battery power to complement engine power is within predetermined battery power maximum and minimum limits; and
controlling battery power to avoid exceeding battery power limits thereby preventing the battery from overcharging or over-discharging.

[c16] 16. The method set forth in claim 13 wherein the step of determining driver demand for power includes the step of accounting for electrical losses in the powertrain whereby the effective demand for power is the sum of the driver demand for power and electrical power losses.

[c17] 17. A closed-loop power control system for a powertrain for a hybrid electric wheeled vehicle comprising:
an engine defining in part a mechanical drive system;
a battery, a motor and a generator defining in part an electric drive system;
the engine being connected drivably to the generator;
the generator being electrically coupled to the motor and the battery;
transmission gearing drivably connecting the motor to vehicle wheels whereby the engine, the generator, the motor and the transmission gearing define a series power flow configuration;
a first controller for coordinating power distribution from the engine and the battery to effect optimal powertrain performance within predefined battery charging and discharging limits;
a second controller for receiving a request for battery power; and
a closed-loop feedback system for monitoring actual battery power during an operating interval and deter-

mining an error between the actual battery power and a requested battery power;
the second controller being connected to the closed-loop feedback system and including a software algorithm for adjusting a battery power request during transient and steady-state operation to change the request for engine power whereby the error becomes zero, thus minimizing unnecessary battery usage due to transient operating conditions.

[c18] 18. The control system set forth in claim 17 including a vehicle system controller, the vehicle system controller comprising means for limiting power distribution to the traction wheels, following a driver demand for power, to power values within predefined power maximum and minimum limits.

[c19] 19. The control system set forth in claim 18 including a vehicle system controller, the vehicle system controller comprising means for incrementing a driver demand for power by an amount equal to electrical power losses in the driveline whereby the incremented driver demand for power is limited to the predefined maximum and minimum power limits.